while a forward pair were adapted to recording with a Marey's drum. For comparison, the motions of the lower jaw under the action of antagonistic muscles were also experimented upon. The rhythm of most rapid contraction and relaxation proved at first slower in the masseter than in the others, but practice equalized the rate, though it seems to be effective only in shortening the stage of contraction. Such experiments, however, are not suited to determine the real reaction time for inhibition. When that was measured directly by reacting with relaxation to an electric shock, the inhibition time was found to be the same as that for excitation, and the equality continued through variations of the intensity of the shock, fatigue, alcohol dosing, etc. The simple reaction time for the jaw motions was, closing 0.15 s., opening 0.17 s.; for the masseter, contraction, before practice 0.25 s., after practice 0.15 s.; relaxation, before practice 0.30 s., after practice 0.14 s. Interesting experiments were also made on the variations introduced by the strength of the spring that pressed the arms of the apparatus against the muscle. If the subject intended to cause a slight motion and the spring was stiff, the reaction time was decreased; if under the same circumstances he intended to make a considerable motion, the time was lengthened.

*Ueber Wiedererkennen. Versuch einer experimentellen Bestätigung der Theorie der Vorstellungsassociationen.* ALFRED LEHMANN, Ph. D. Philos. Studien, Bd. V (1888), H. I, pp. 96–156.

Can all the phenomena of association be explained by the law of *contiguity?* This is the problem that Dr. Lehmann attempts to solve. From the standpoint of association by contiguity, recognition of simple impressions is possible, in the author's opinion, only under two conditions: first, that the memory-picture of a former sensation still exists, with which the later sensation may be compared; or, second, that a name or the like has been associated with the sense impression. The latter is not strictly recognition, but is so called. Dr. Lehmann's experiments, performed with sensations of light, cover both cases.

In the investigation of the first case, the different shades of gray, produced by means of rotating disks partly black and partly white, were employed. The disks were shown by means of a carefully prepared apparatus, in the following manner. First, a disk of normal shade was shown. After the lapse of an interval the normal disk was again shown; or a disk of lighter shade, or one of darker shade appeared. The observer judged whether the disk last shown was like or unlike the former one. In the first set of experiments only two disks were used. The interval was 30 sec. The normal disk was half black and half white, *i. e.* it = 180° black + 180° white. The other disk varied between 240° white + 120° black and 188° white + 172° black. Under these conditions, as the amount of white in the disks decreased, the average number of correct answers in each series of 30 experiments fell from 29 to 18 with one observer, from 27 to 17 with the other; the number of correct answers likely to occur by chance being of course 15. Thus as the difference between the normal disk and the light disk decreases, the number of correct answers diminishes. In another set of similar experiments three disks were used; and the light disk was always as many

degrees lighter than the normal disk as the dark one was darker. Six series of 30 experiments each showed a decrease in the number of correct answers, especially as the disks approached one another in shade. Thus an increased number of possible impressions decreases the number of correct answers. Varying the time-interval, five series of 30 experiments each showed that, as the time increased from 5 sec. to 120 sec., the number of correct judgments decreased with one observer from 30 to 17, with the other from 21 to 17. Individual differences due to inclination, talent, and other personal conditions are here apparent. The effect of practice was also noticeable, the second half of a series generally showing more correct answers than the first half. Thus far, in the author's opinion, the theory of association by contiguity satisfies all demands as an explanation of the recognition of simple impressions. Dr. Lehmann further argues that on the hypothesis of association by similarity, the observer would more frequently recognize the normal disk (when three are used) than either of the others, because it is shown more often. But on the supposition of recognition by contiguity, provided the memory picture of the normal disk be distinct, no such difference would appear, but the probability of error would be just as great with one disk as with another; while if the memory picture of the normal disk be indistinct, it would be recognized less frequently than either of the others. The results of the experiments favor this view. B, with a clear memory, making only 107 errors, misjudged the normal disk 55 times, the other disks 52 times. L, with a vague memory, making 165 errors, misjudged the normal disk 109 times, the other disks only 56 times.

In the investigation of the second case—that of recognition by means of a name or designation—Dr. Lehmann used scales with black and white as the outer parts and a varying number of intervening shades of gray. First, one of these scales was shown; then, after an interval, the different shades were shown separately, and the observer judged of their place in the scale. Here it would be expected, if recognition occurs through a name, that, when the number of shades is not greater than the names of gray in daily use, nearly all the judgments would be correct, and that when more shades are employed, many errors would occur. Experiment confirmed this supposition. With a five-part scale—black, dark gray, medium gray, light gray, white, the number of shades of gray here corresponding to the names in common use—96.7 per cent of the judgments were correct; with a six-part scale only 70.6 per cent were correct; with a nine-part scale, only 46 per cent (the minimum number of correct answers to be expected by chance would be 37 per cent with a nine-part scale). The hypothesis that recognition here occurred by means of association with a name was further corroborated by experiments with a nine-part scale, where by simply associating a number with each shade, 75 per cent of correct answers were obtained. To obtain still further proof of recognition through a name, another set of experiments were performed similar to those first described, except that before each experiment the two disks used were simultaneously shown, thus enabling the observer to note the difference between them and to give them designations. This increased the number of correct answers. In these cases, if the name is the means of recognition, then the amount of difference between the disks, provided it be sufficient to be perceived, ought to

have no influence upon the certainty of recognition. Nor should the time elapsing, nor personal conditions, nor practice have any considerable influence. The results of Dr. Lehmann's experiments gave support to all these inferences. Hence he concludes that the theory of association by contiguity explains all the phenomena of recognition, and that the theory of association by similarity, which cannot explain them all and sometimes is in conflict with experience, is superfluous. W. H. B.

*The Senses of Animals.* SIR JOHN LUBBOCK. pp. xxix, 292. International Scientific Series. D. Appleton & Co., N. Y., 1888.

Having been obliged to look up a great deal of literature on the subject of the senses of animals, Lubbock has put together into a book the information laboriously arrived at, for the sake of making the path of the next explorer easier than his own has been; and he has thrown in some observations of his own, additional to those heretofore published, besides some acute criticisms of the reasoning of other observers. The result is somewhat heterogeneous, but it is interesting all the same; it is not necessary that every book that is printed should be a harmonious whole. The list of books and papers consulted by him is very long, but Graber's latest work on the brightness-sense and the color-sense of animals seems not to have reached him at the time he wrote. This is strange, because it bears the date of 1884; and it is unfortunate, because it may be considered as the only absolutely thorough and scientific experimental investigation of those senses in animals that has yet been made. Graber determined the absorption spectrum of all his colored glasses and colored solutions, and the exact intensity of the light which they transmitted; he found out how strong the preference of each animal was for brightness or for darkness before testing its preference for colors; he offered his animals the choice between only two compartments at a time, rightly considering that to ask them to bear in mind their sensations long enough to choose between five or six was putting too great a strain upon their mental powers; he made with each pair of colors two sets of experiments, once with one color the brighter and once with the other color the brighter. None of all these precautions were taken by Lubbock. Graber worked under many disadvantages and with much lack of means for procuring desirable apparatus; he speaks with real grief of the fact that Lubbock, with rich laboratories at his command, did not proceed in a more systematic fashion. As regards results, concerning bees, for instance, they obtain for preference-coefficients compared with red, respectively,

| | R | Y | G | B | W |
|---|---|---|---|---|---|
| Lubbock, | 1 | 1.02 | .96 | 1.5 | 1.19 |
| Graber, | 1 | 2 | 2 | 6 | 18 |

The only agreement is that, of the colors, blue is the favorite. Lubbock finds that white is only slightly preferred to red; Graber that it is visited eighteen times as frequently. Graber finds besides that both blue and white with ultra-violet are three times as agreeable to bees as without ultra-violet.

The book contains much that is interesting on the instincts of some animals, especially bees, and on the intelligence which they